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Spray cooling technology promises better capability for high power electronics

by Michael Kelly, Propulsion Directorate

WRIGHT-PATTERSON AIR FORCE BASE, Ohio — A small team from the Air Force Research Laboratory's Propulsion Directorate is eager to supply future capabilities with studies they're conducting. The team is tackling the ever-increasing problem of space thermal management — the cooling of powerful electronic devices used in space vehicles like satellites, the space shuttle and the International Space Station.

Led by Dr. Kirk Yerkes, an expert in fluid mechanics engineering, the team's challenge is to get rid of heat generated by more and more powerful semiconductors and electronic devices filling the bellies of these space-based beasts.

Most currently generate very low heat fluxes and can be removed by the flow of air over the hot device — but as performance of small electronic devices steadily increases, heat removal from these devices for space use is approaching critical limits, according to many space industry and NASA experts. Computer chips just an eighth of an inch square will soon emit as much heat as a 100-watt light bulb, according to NASA officials.

To combat this problem, scientists and engineers have developed "spray cooling" technologies using liquids such as water or ammonia to remove high heat fluxes from the hot surfaces of aircraft electronic components, Yerkes said.

The concept is similar to humans sweating, or evaporating moisture to cool the body, he said. However, unlike humans, electronic packages don't sweat and need a little help to cool down, which is where the "spray" comes in. Coolants are sprayed onto electronic packages and circuit boards, where they heat up by conduction and evaporate, providing life-saving cooling.

Yerkes, who helped research and develop existing "spray cooling" systems for electronic components in military aircraft, hopes to extend this proven technology into the world of microgravity. He and his team are in the process of building the hardware for a series of tests co-sponsored with NASA on the famous "Vomit Comet," a KC-135A that simulates microgravity — or weightlessness — conditions like those in space.

The experimental hardware buildup is nearing completion and Yerkes hopes to fly his spray chamber sometime this fall from the NASA Glenn Research Center in Cleveland, Ohio. He and his team are already Air Force and NASA flight qualified and ready to endure as many as 160 parabolas — flight maneuvers in the KC-135A to simulate weightlessness on four research flights over the course of a week.

In fact, they recently flew for the first time aboard NASA's KC-135A micro gravity test bed with a boiling experiment supported by the University of Maryland and NASA. AFRL researchers observed NASA's flight test process and became acclimated to conducting experiments in a micro- and high-g environment during these first flights.

"Our whole focus is to take spray cooling technology into the space environment because it represents a new capability for cooling certain technologies like lasers for surveillance or diagnostics for satellite instrumentation," Yerkes said. "There's also a need to cool military airborne and spaceborne platforms for directed energy weapons along with any number of systems that generate what we call high heat flux," he explained.

His biggest challenge will be demonstrating and identifying the spray cooling properties in a microgravity environment. It's a new frontier for the researcher with specialized background in heat mass transfer.

"The thermo physics of how these sprays work, or even if they'll work at all in this type of environment aren't known," Yerkes said. "The whole idea is to take away enough heat [from electronic components] that it makes a difference.

"Ultimately, once we start identifying those physics issues through our upcoming experiments, we can work with NASA to get long term space flights," he said. "Things might run for a while in transient short bursts of a microgravity environment but when it gets up into space and goes on for days and weeks then

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things could go wrong."

If successful, Yerkes' experiments could pave the way for satellites carrying more high-powered components onboard. @